Coffey & Kent

Interior Illumination of the University of Illinois Auditorium

Electrical Engineering

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INTERIOR ILLUMINATION OF THE UNIVERSITY OF ILLINOIS AUDITORIUM

BY

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THESIS

FOR

DEGREE OF BACHELOR OF SCIENCE

IN

ELECTRICAL ENGINEERING

COLLEGE OF ENGINEERING

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Elmer Washburn Coffey and Lee Corson Kent

ENTITLED Interior Illumination of the University of Illinois Auditorium

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF Bachelor of Science in Electrical Engineering

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INTERIOR ILLUMINATION

OF THE

UNIVERSITY OF ILLINOIS AUDITORIUM

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INTRODUCTION

Only in the last few years has the illumination of buildings and interiors been considered from the artistic side as well as from the standpoint of utilization. The art of illumination was given a big forward impetus a few years ago by the successful application of tungsten and other metallic filaments in incandescent lamp manufacture. The increased efficiencies thus gained have practically opened that new field of Engineering known as Illuminating Engineering. The recentness of the growth of this field is shown in the fact that at the time the Auditorium of the University of Illinois was built in 1907, many of the principles of Illuminating Enginerring now so widely advocated and accepted were not in practical use.

It is with the object in view of studying the present conditions and suggesting and, if possible, securing changes in the lighting of the interior of the Auditorium to make it more artistic, up-to-date, and efficient according to the best principles of Illuminating Engineering that this thesis is undertaken.

DISCUSSION OF PRESENT CONDITIONS

While the illumination at the Auditorium at the present time cannot be said to be inadequate there is still a great deal of room for improvement in both quality and quanity and in general effects. As will be seen from the data on page 24 the intensity on the stage varies from 0.82 candle feet at a point near the side to 1.73 candlefeet at a point directly under the lights. These intensities were measured with a Sharp Miller Portable Photometer which measures the illumination in a comparative way with that of a standard lamp.

One noticable feature which in a way accounts for the discrepencies in the results is the voltage regulation at the Auditorium. With a voltmeter at the switchboard the voltage was found to vary between 103 and 112 volts which produced a very noticable effect on the 110 volt carbon lamps. This is very objectionable here as well as noticable and always draws the attention of the audience to the lighting fixtures. This effect could be overcome to a great extent by the use of tungsten lamps in which the candle power is not as susceptable to voltage change as in the carbon lamp.

It was not thought necessary to take a great number of positions on the stage from which to take readings, so that a few were selected which cover almost any condition. Refering to the drawing of the stage plan on page 25 position "A" is the place usually occupied by the pulpit or

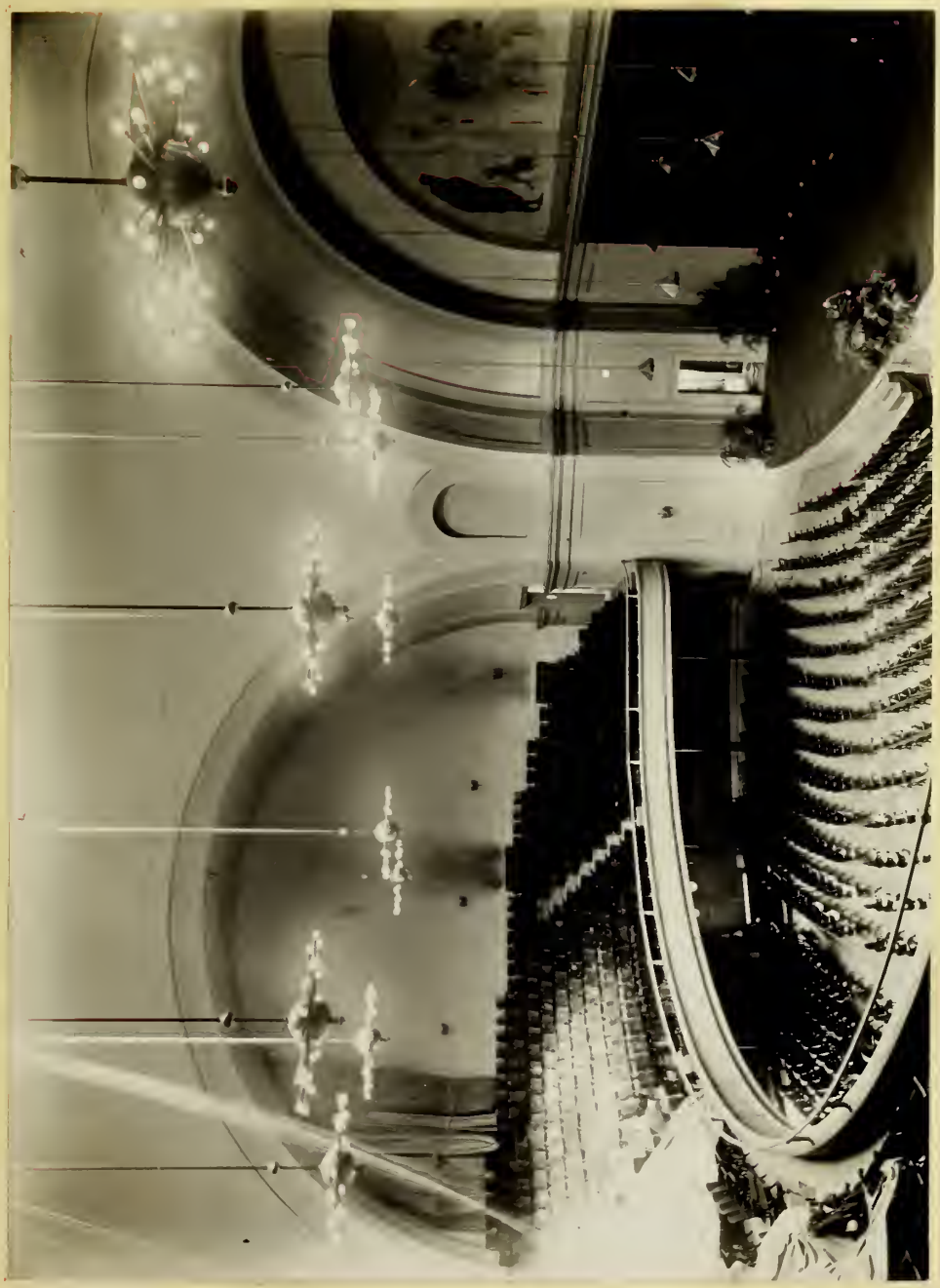
reading stand; position "B" was directly under one of the lights; position "C" was an extreme position only used at the time of Choral Concerts or other similar numbers; and position "D" was in the middle of the back of the stage. At positions "A" and "C" it is seen that the intensity from the general illumination or dome fixtures is about as great as that from the stage fixtures. These readings were taken on a plane about four feet above the floor, which is about the place that the average person holds a book when standing. These data also show very non-uniform lighting over the stage which is very undesirable.

Perhaps the greatest objection to the present fixtures over the stage is from the artistic standpoint. As will be seen from the photo on page 4, these fixtures are suspended by very long straight rods from the arches over the stage. While the long rods are undoubtedly out of place in the Auditorium where long curved lines predominate, the worst effect is on the beautiful painting of The Return of Ulyses by Millet which is in the arch over the stage. It is especially noticable from the balcony that these long rods give the appearance of bars before the painting and in imagination the figures almost become animals in a cage. Thus it is seen that it is certainly most desirable that the rods be removed and the fixtures raised both to give a more uniform illumination on the stage and avoid the spoiling of the effect of the painting.

In the general illumination of the Auditorium from the dome fixtures the lighting is not what it should be.

From the illuminometer readings on page 26, it is seen that the intensity on the main floor varies from about 1.15 candle-feet directly under the dome to 0.60 candlefeet at the sides and 0.35 candlefeet under the balcony. This again shows a non-uniformity which would suggest a raising of the fixtures. From the balcony there is another objectionable feature which could be remedied by raising the dome fixtures. At present they are so low that they actually come in the line of vision of those seated in the higher seats of the balcony and this is always to be avoided. The high intrinsic brilliancy of the bare carbon lamps is very injurious as well as tiring to the eyes and if nothing else could be done they should be replaced with frosted lamps to cut down the intrinsic brilliancy. The photo on page 6, taken from one of the higher seats at the side of the balcony, shows the appearance and position of these fixtures.

Again the painting over the stage suffers because of these fixtures. They are all placed in the same plane and the massive balls which form the centers of the fixtures and the large number of arms that carry the lamps cast a ring of heavy shadow all around the walls of the Auditorium. This ring of shadow falls on one of the most delicate parts of the painting and what should be a faintly tinted canopy becomes a heavy dark mass. This too could be remedied by raising the fixtures and not necessarily putting them all in the same plane. The illumination in the balcony is fairly uniform, varying from an intensity of 0.60 candlefeet in the back parts to about 1.10 candlefeet near the front and 0.85



candlefeet at the sides. Both for these specific reasons and for general effect it would be desirable to raise the fixtures a great deal and perhaps redesign them for better efficiency. As it is half of the light is thrown to the ceiling and dome and very little of it is reflected. By the proper use of reflectors much less light could be directed to give the same or greater illumination. One commendable feature of the general illumination at present is that the intensity under the balcony is nearly the same as that in front of it. This removes the objectionable feature so often found in places of this kind where the general illumination gives a distinct line of shadow thrown by the edge of the balcony. This is overcome by the soffit lights on the under side of the balcony. These however are not quite as effective as is possible but could be made so by a few more or larger lamps. The original installation here was of frosted lamps as it should be but some renewals have put in bare lamps and the high intrinsic brilliancy is objectionable to those persons sitting in the elevated rear seats of the main floor.

PROPOSED CHANGES

In pointing out some of the faults of the present system in the preceding divison a number of changes have been suggested.

The present stage fixtures are quite out of place in a building such as the Auditorium; they are too ornate for such surroundings. They would well do in a building like the Library or Lincoln Hall but in the Auditorium they do not harmonize with the massiveness as suggested by the large dome and general construction of everything. In the Library or Lincoln Hall they would be seen by everyone and their beauty could be appreciated. These eight stage fixtures will be removed and placed in the Woman's Building.

Four fixtures with a much shorter drop, hung from the outlets that at present support the front four long fixtures will be substituted. The four fixtures at present hanging from the back outlets are within three feet of the back of the stage and the light from them is very seldom of any use. Hence these fixtures were thought useless. The four new fixtures to hang from the front arch will be supported by chains since these will harmonize with the curved lines of the arches and the entire dome better than the straight stiff rods. These new fixtures will also be designed with curved sides for the same reason. They will be open at the bottom and a large silver-plated reflector will be hung inside of each so as to throw the light from a 150 watt tungsten lamp downward. In this way practically all the light will be thrown on the stage. The apparent vertical candlepower of each of

the four reflectors is approximately 800 candlepower which is sufficient to give very good illumination over the whole stage.

With these new fixtures the unpleasant light that was in the direct range of vision of everyone in the audience with the old fixtures will be done away with. Also the long rods which are in front of the large painting by Millet will be gone as the new fixtures will clear the painting entirely and thus remove everything from in front of it and give the audience a clear view.

To remedy the faults of the eight dome fixtures it is proposed to raise them to within about six feet of the dome and at the same time redesign them for more efficient distribution. As they are now, nearly one half of the light is wasted and by raising them and using properly designed shades the same light could be thrown on the floor to give better illumination and distribution.

The rods supporting the three chandeliers in the arches over the balcony would also be shortened and the fixtures redesigned with proper shades to give the desired uniform illumination over the balcony. We would not advise that these be changed in the same way as the eight dome fixtures however. By making these three fixtures different from those hanging from the dome the monotony of too many similar fixtures will be avoided.

By using tungsten lamps instead of carbon lamps the quality of light will be greatly improved and the whole appearance will be more pleasing. For uniformity of the

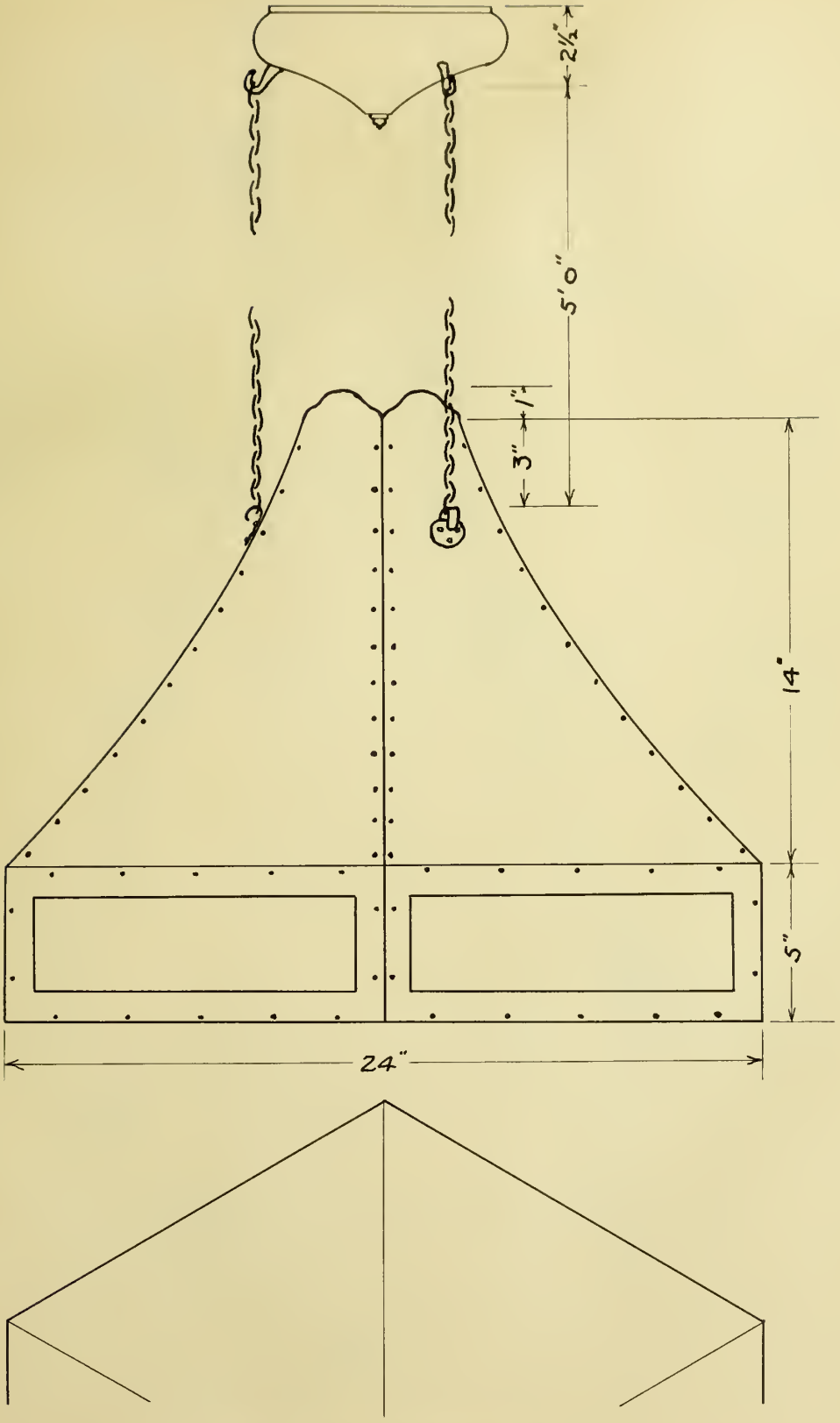
color of the lighting tungsten lamps should be used in all of the wall brackets and in the soffit fixtures under the balcony. Since it is intended to increase the brilliancy on the floor from the dome fixtures the lights under the balcony would have to be increased in size to preserve the equality of the illumination under the balcony as compared to that out from under it. The substitution of 25 watt frosted tungsten bulbs in place of the present 16 candle-power lamps would give at least twenty percent more light of the desired color.

One fault that has been found with the Auditorium illumination that will not be remedied by any of the above changes is, that while the general illumination for reading purposes is adequate, yet the face of the speaker or performer on the stage is not lighted as brilliantly as it should be for anyone in the audience to see the facial expressions satisfactorily. Foot lights would remedy this but many speakers object to stage footlights in a place like the Auditorium. To accomplish the desired result without bringing forth the objection we propose to put in a medium sized tungsten lamp at each side of the stage in the front corner where the front of the balcony joins the stage panelling. This point is designated by "X" on the drawing on page 28. By using the proper opaque shade of a correct design the light would be kept out of the eyes of those in the audience and would illuminate the face of anyone on the stage thus giving the desired result.

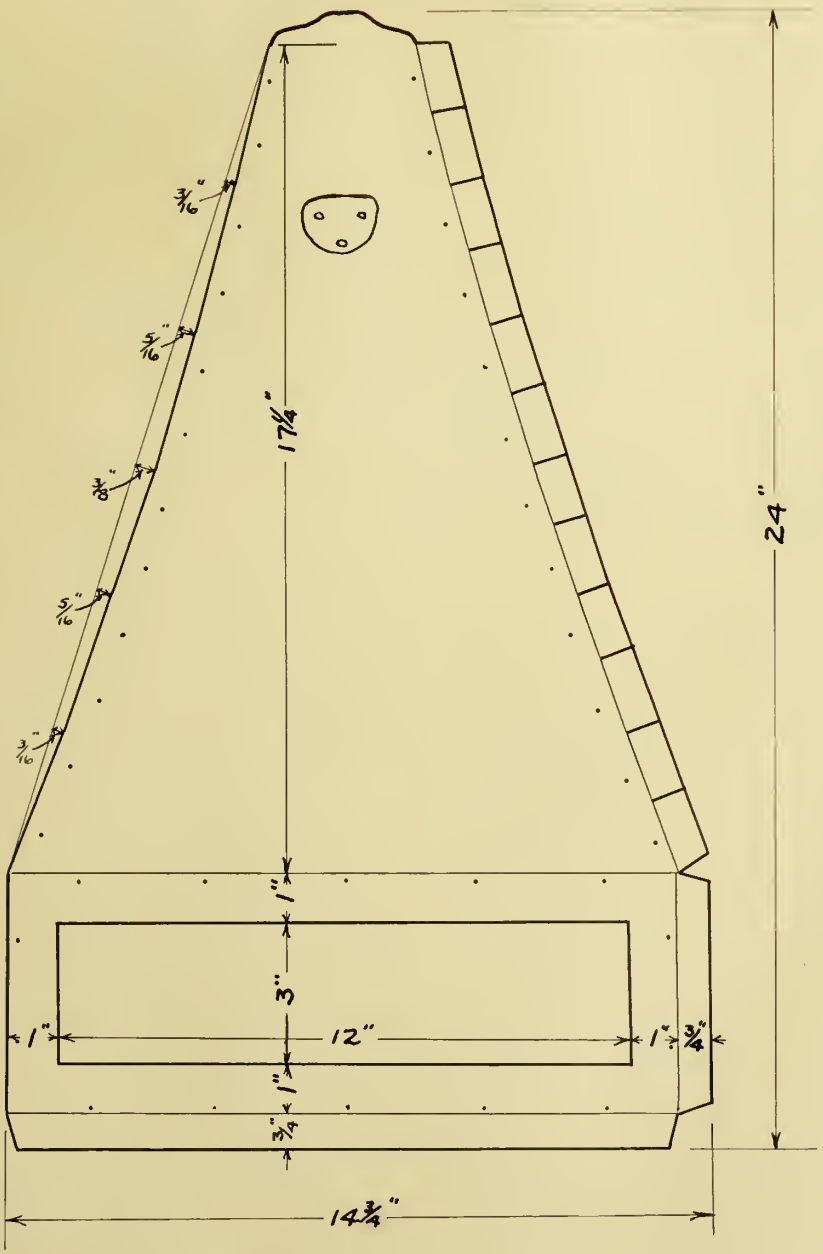
DESIGN OF NEW FIXTURES

The design and construction of the new fixtures for the stage took up a large percent of the time used in the preparation of this thesis. Under the suggestions in the discussion of present conditions and proposed changes a great deal of the design of these fixtures has been determined. It was decided that the fixtures should have a total drop of about six feet. They were to be hexagonal in shape, have an open bottom, have art glass in the vertical part of the shade, and have the slanting part concave. The next step was to make a number of drawings to determine the proper proportions. From one of these drawings a paper pattern was made and a light cardboard shade with tissue paper in place of glass, constructed with the proper dimensions. In order to study the appearance of this in place it was drawn up into the arch by a wire and its proportions studied from below. A few minor changes in the dimensions were decided upon and four other shades constructed of heavy cardboard with dark green art glass in the sides. The drawings on pages 12 and 13 show the dimensions used. Brass paper fasteners with round heads were used as rivets. A galvanized sheet iron form was riveted together and hooks for the supporting chains fastened to this. This form fitted into the top of the cardboard shade and supported the heavy glass reflector and lamp that actually gave the distribution desired.

From a study of various catalogs the "Helmet" reflector No.755 made by The National X-Ray Reflector Company of Chicago was decided to be the best one for the



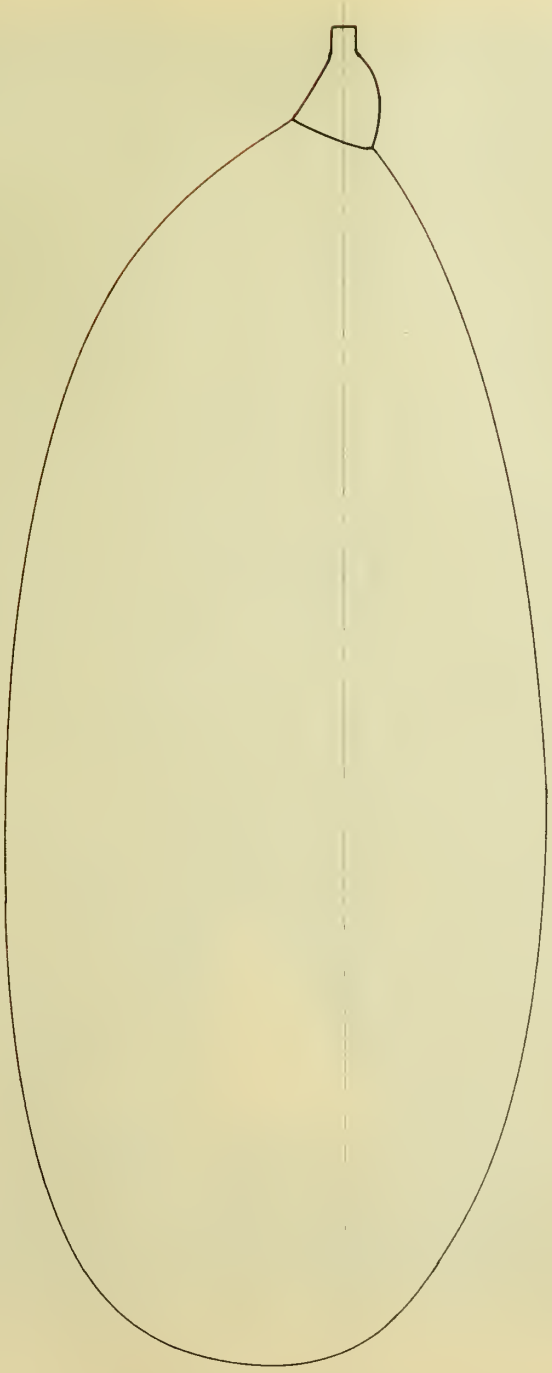
NEW STAGE FIXTURE



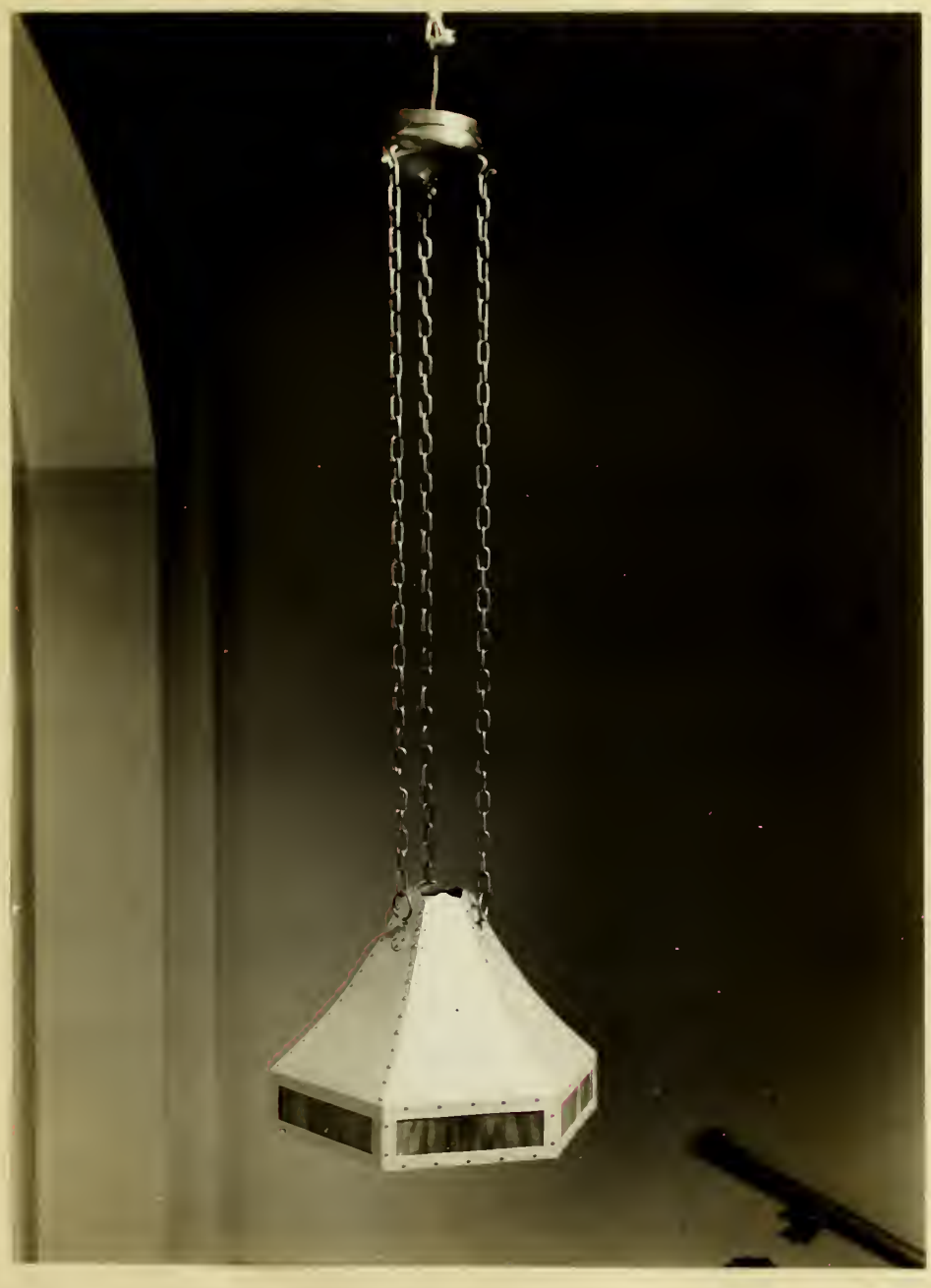
PATTERN FOR SIDE OF STAGE FIXTURE

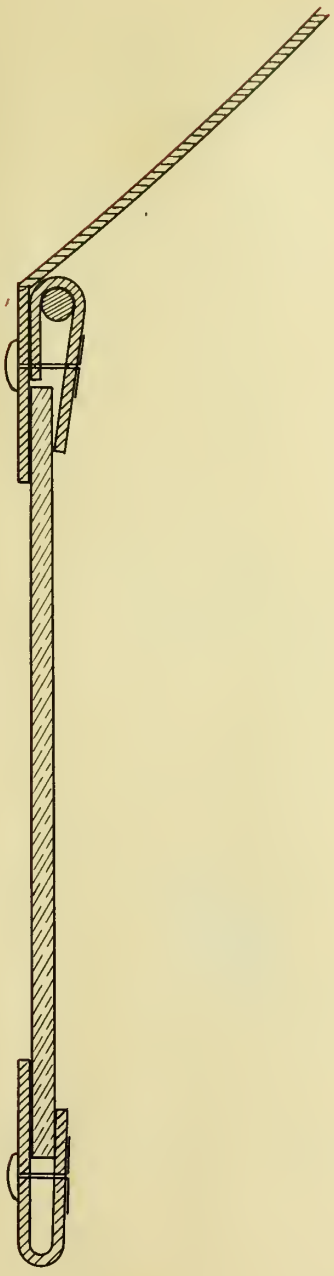
purpose. This is a type of focusing reflector designed to throw a strong light downward and to the back, and was designed primarily for show window lighting. Page 15 shows the distribution curve of this reflector with a 150 watt tungsten lamp. These reflectors fit inside of the shades and will be turned to throw the light to the back of the stage since they will be hung from the front outlets over the stage. Page 16 shows a photo of one of these fixtures complete with chains and canopy. These chains and the canopy are finished in antique brass and it is expected that the cardboard shades will later be replaced by metal ones to correspond to the chains and canopy. In the cardboard shades a heavy steel wire was put in above the glass to give stiffness to the shade. Page 17 shows several details of the construction of the shade.

In the design of the new dome chandeliers, the old ones will be used to a very great extent. The drawing on page 19 shows one of the old fixtures. Eighteen of the twenty-four arms of each of these will be removed entirely, four of the remaining arms will be left just long enough to support a socket and in each of these will be placed a 40 watt round frosted bulb tungsten lamp. These will serve to enliven the appearance of the fixture and will illuminate the ceiling of the room. On two long arms opposite each other and midway between the lamps just mentioned will be put the two large lamps to give the illumination for the floor. Instead of the horizontal sockets, drop link sockets will be used so that the lamps will hang vertically. 100 watt



DISTRIBUTION CURVE OF "HELMET" REFLECTOR

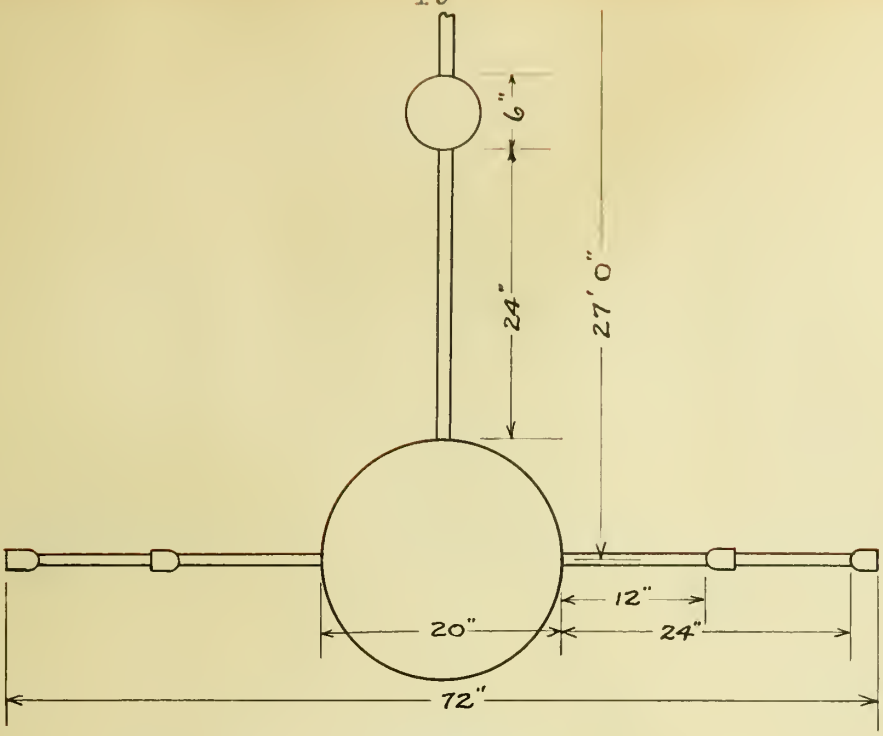


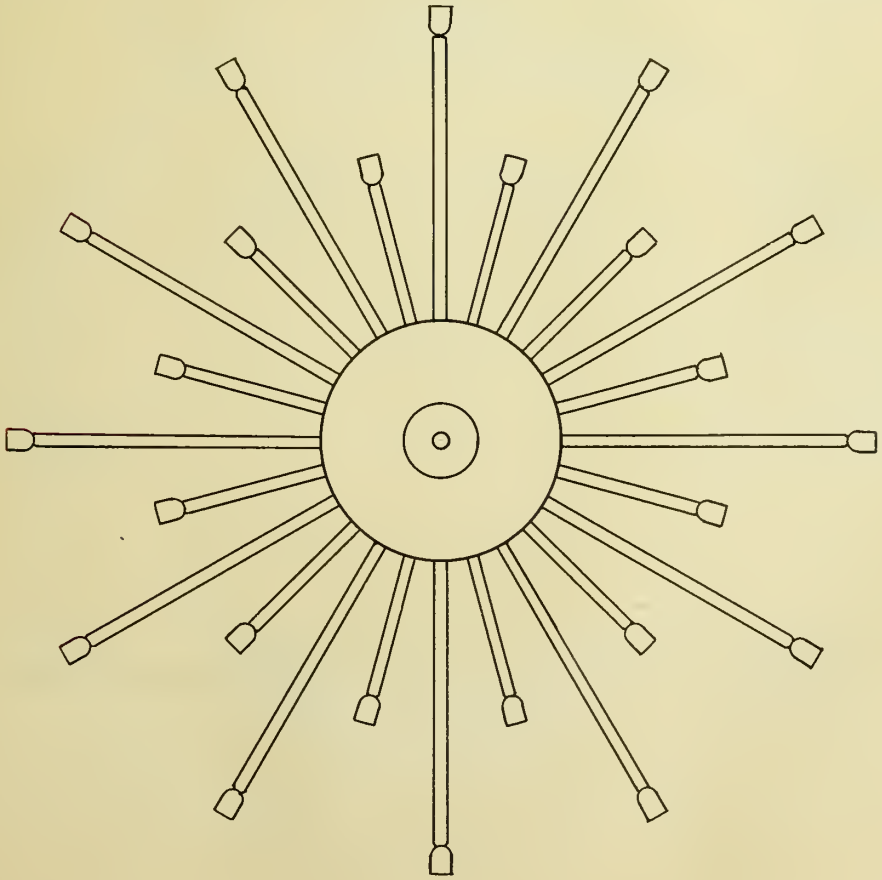


METHOD OF FASTENING GLASS IN SHADE

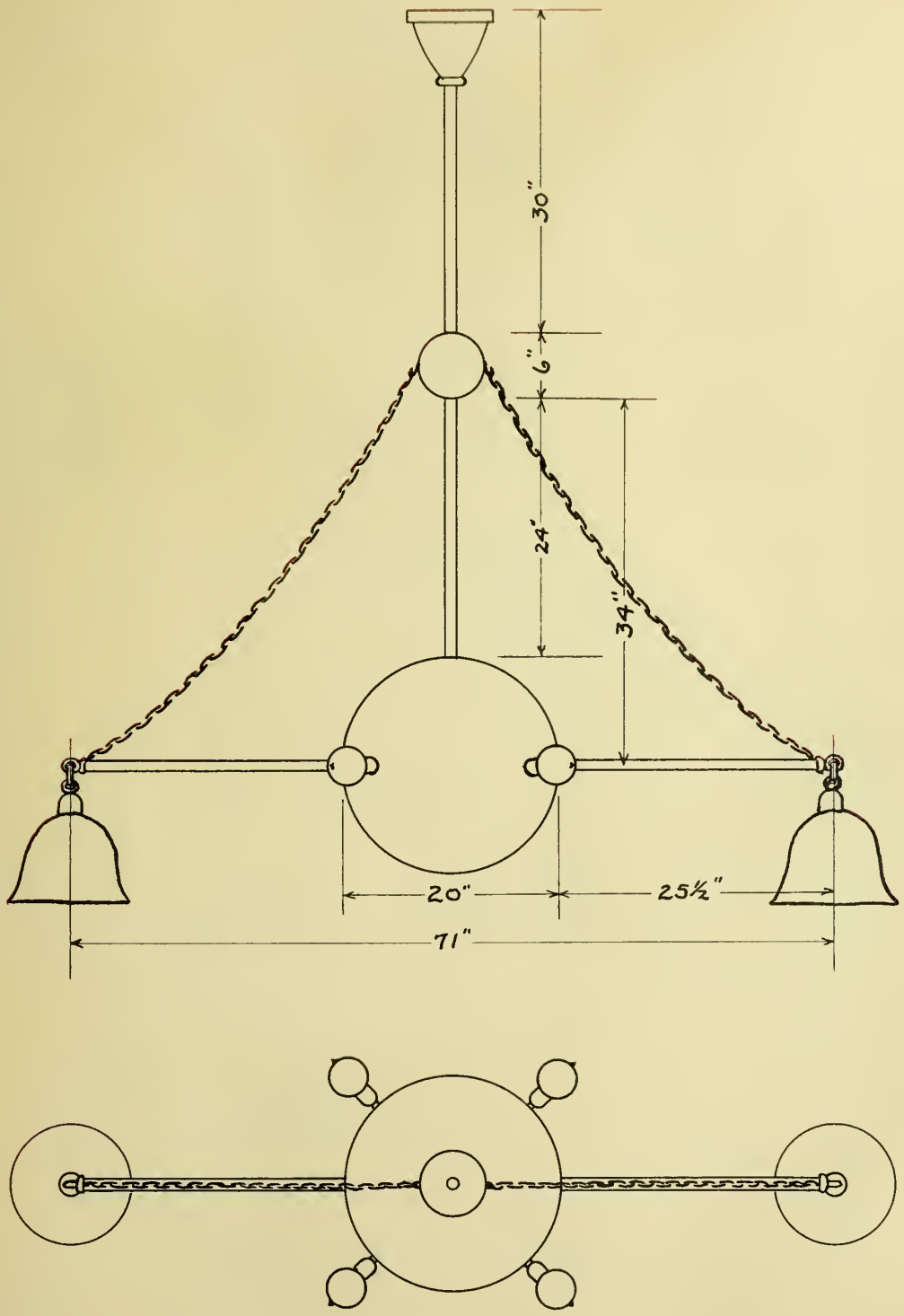
clear tungsten bulbs with "Holophane" shades of the intensive type will be used. From the height at which these will be hung, these shades will give the desired illumination on the main floor while the balcony chandeliers and the round frosted bulbs on the dome fixtures will give adequate illumon the balcony. The two long arms will be supported from the upper ball in the rod by two light-weight chains. These will give a more pleasing appearance to the fixture and will also help support the weight of the shades and lamps at the ends of the long arms. The drawing on page 20 gives an idea of the new design. The eight fixtures will be turned so that the long arms will form a circle around the dome.

In the design of the three balcony chandeliers it was decided that a shower effect could be made very artistic in appearance and effective in distribution. These fixtures will also be raised to within six feet of the top of the arches. Six pendant chains from arms about four inches in length, equally spaced around the ball, will be used to support 40 watt frosted-tip tungsten lamps with "Holophane" extensive shades. These drops will have a total length of twenty-four inches. Page 21 shows a drawing of the new design.

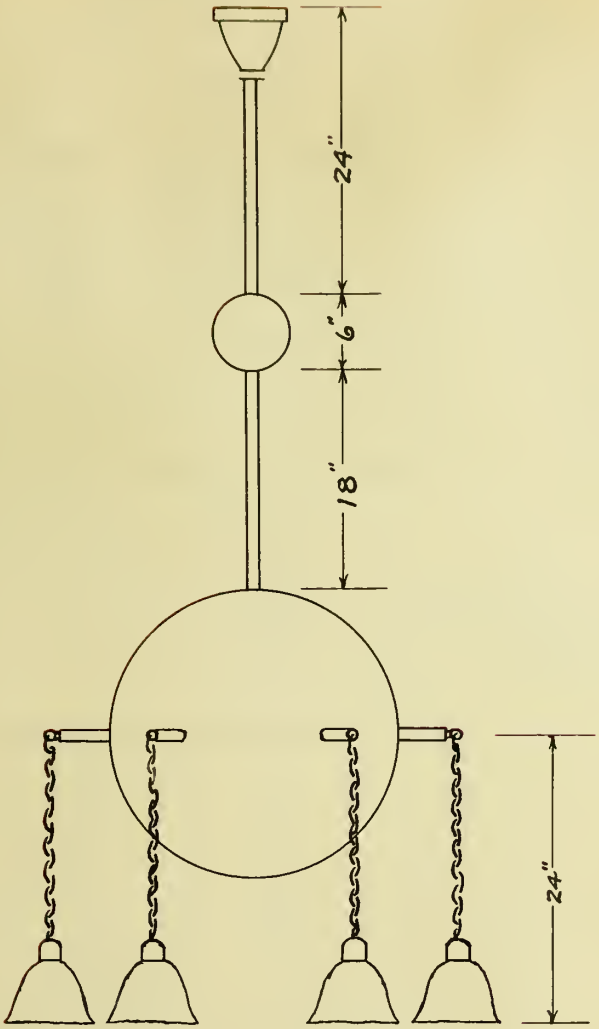


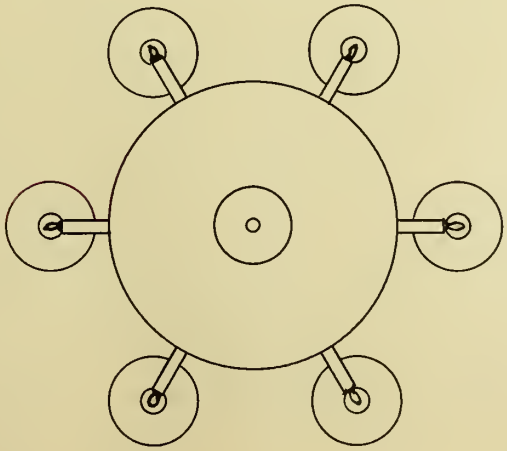


OLD DOME CHANDELIER



NEW DOME CHANDELIER





BALCONY CHANDELIER

DISCUSSION OF RESULTS

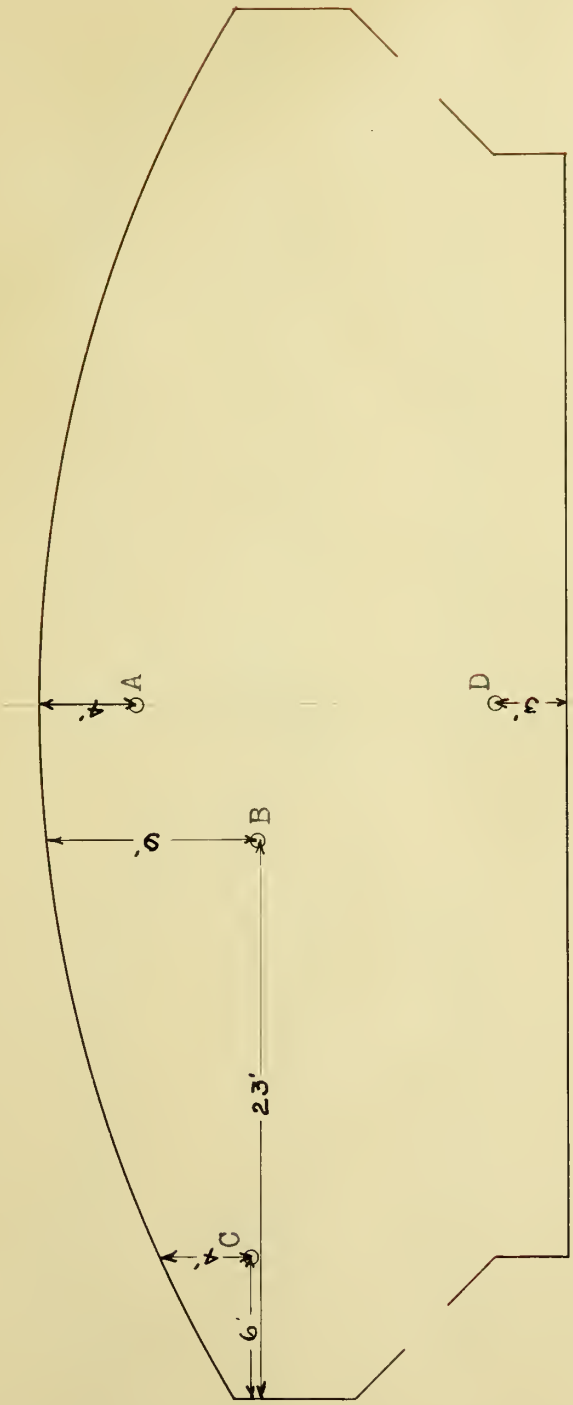
At the time of this writing only the stage lights have been changed. The results from this change have been more than satisfactory. The light on the stage floor is much better and more uniform than before, the intensity now varying from 1.8 candlefeet in the worst position "C", to 2.4 candlefeet near the front center of the stage, this being the position used most. Page 30 gives a comparative table of the intensities before and after the change. It is seen that the illumination in the poorest parts is now better than in the best parts before the change was made as there is now much more uniformity. Page 31 shows the difference in power consumption, there now being required only about 40% of the power used before. The light is whiter and clearer. Fine print can easily be read anywhere on the stage without tiring the eyes, as the illumination is much more satisfactory and more pleasing.

From any place in the seat area the unpleasant light from the old fixtures is gone. The new fixtures are up so high as to be almost unnoticeable to anyone in the audience, especially those on the main floor. This is a very desirable feature in any illumination system. The painting by Millet shows up better than before the old fixtures were taken out, the suggestion of bars in front of the painting is done away with and the whole appearance is very much improved. On page 23 is a photo of the new installation.

DATA
STAGE ILLUMINATION IN FOOT CANDLES
OLD INSTALLATION

POSITION		STAGE ONLY	GENERAL ONLY	STAGE AND GENERAL
"A"		.675	.732	1.210
		.630	.719	1.190
		.728	.640	1.230
		.688	.695	1.280
	Average	.681	.697	1.228
"B"		1.610	.580	1.700
		1.700	.660	1.814
		1.710	.662	1.720
		1.682	.580	1.700
	Average	1.676	.621	1.734
"C"		.540	.503	.780
		.560	.490	.810
		.530	.480	.830
		.560	.490	.860
	Average	.548	.491	.820
"D"		1.640	.220	1.700
		1.730	.280	1.720
		1.790	.240	1.800
		1.620	.240	1.710
	Average	1.695	.250	1.730

These positions are indicated on the plan of the stage on page 25.



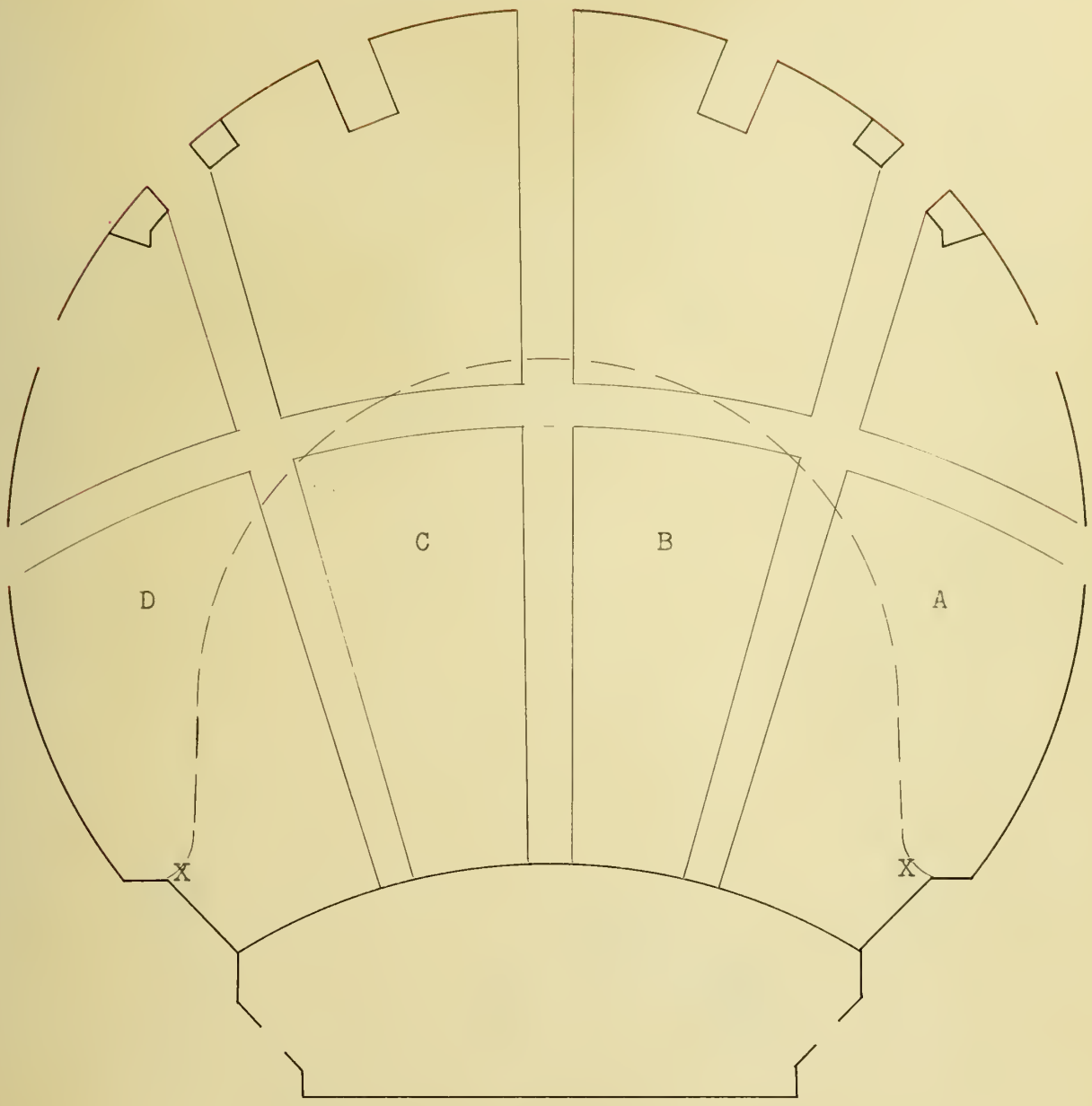
PLAN OF STAGE

DATA
MAIN FLOOR AND BALCONY ILLUMINATION
INTENSITY IN FOOT CANDLES - OLD INSTALLATION

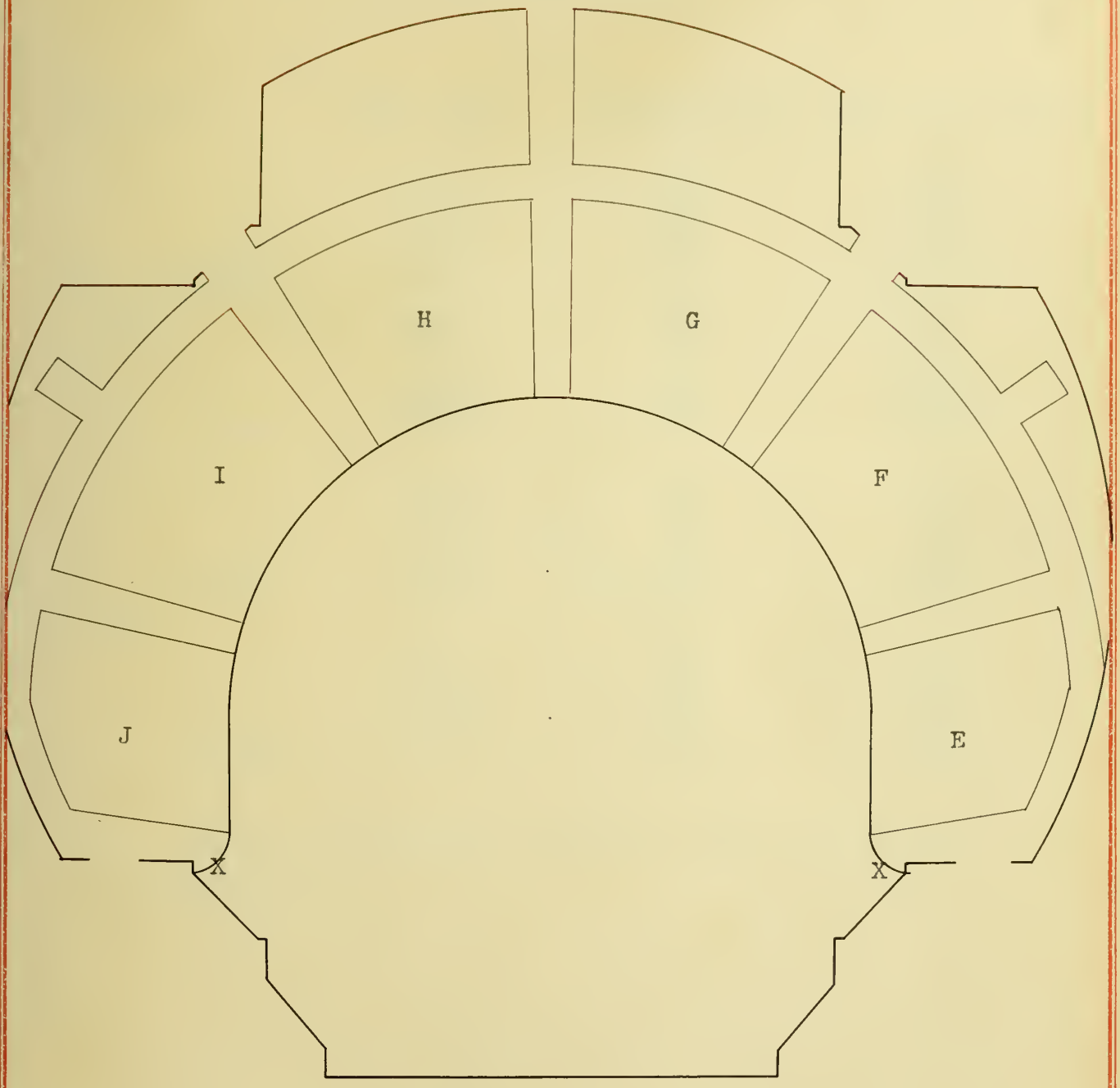
MAIN FLOOR

POSITION	READINGS 1	2	3	4	AVERAGE INTENSITY
BC-15-0	.870	.915	.936	.912	.908
B -22-7	.342	.400	.365	.400	.377
C -22-7	.320	.295	.308	.355	.326
B - 8-5	.760	.800	.835	.835	.807
A - 8-9	.645	.690	.662	.690	.672
AB-15-0	.880	.935	.910	.960	.921
CD-15-0	.865	.830	.810	.840	.838
D - 8-7	.910	.950	.910	.960	.930
C - 8-5	1.140	1.160	1.100	1.200	1.150
BALCONY					
J - 5-6	.835	.846	.870	.850	.850
I - 5-8	.880	.840	.856	.850	.850
H - 5-7	.880	.890	.835	.840	.861
H -12-7	.660	.680	.680	.640	.665
G -12-7	.770	.800	.790	.740	.775
G - 5-7	1.150	1.120	1.010	1.020	1.075
F - 5-8	.980	1.010	.970	1.030	.997
E - 5-8	.960	.990	.910	.910	.947

The positions listed refer to the section, row and seat respectively.



PLAN OF MAIN FLOOR



PLAN OF BALCONY

DATA
STAGE ILLUMINATION IN FOOT CANDLES
NEW INSTALLATION

POSITION	STAGE ONLY	GENERAL ONLY	STAGE AND GENERAL
"A"	1.740	.732	2.330
	1.700	.719	2.280
	1.730	.640	2.290
	1.710	.695	2.290
Average	1.720	.6970	2.310
"B"	1.840	.580	2.360
	1.840	.660	2.390
	1.880	.662	2.450
	1.880	.580	2.400
Average	1.860	.621	2.400
"C"	1.380	.503	1.800
	1.380	.490	1.780
	1.340	.480	1.860
	1.300	.490	1.790
Average	1.350	.491	1.807
"D"	1.670	.220	1.900
	1.660	.280	1.850
	1.640	.240	1.800
	1.700	.250	1.840
Average	1.670	.250	1.836

These positions are indicated on the plan of the stage on page 25.

SUMMARY OF DATA
STAGE ILLUMINATION IN FOOT CANDLES

POSITION	OLD INSTALLATION	NEW INSTALLATION
"A"	1.228	2.310
"B"	1.734	2.400
"C"	.820	1.807
"D"	1.730	1.836

DATA
POWER CONSUMPTION IN WATTS

OLD INSTALLATION
Carbon Lamps

	VOLTS	AMPERES	WATTS
EIGHT DOME FIXTURES	105	57.20	6010
THREE BALCONY FIXTURES	108	19.70	2128
STAGE FIXTURES	105	11.98	1258
TOTAL			9396

NEW INSTALLATION
Tungsten Lamps

	VOLTS	AMPERES	WATTS
STAGE FIXTURES	107	5.00	535

The saving of the new stage installation over the old installation in power consumption is 723 watts.

CONCLUSIONS

While we have not yet been able to get all of the changes made that have been outlined here, those that have been made have given very satisfactory results.

The new stage fixtures besides being very much more pleasing to the eye, give a great deal better and more uniform illumination with less than half the power.

From the results obtained already we are convinced that the principles underlying our work are all right and will be borne out by the changes in the dome and balcony chandeliers. Drawings of these proposed changes are in the hands of the Supervising Architect of the University and we have been assured that they will be made in the near future. We regret that they could not have been made early enough so that their results could have been embodied in this thesis.

In closing we wish to express our thanks to Professor Morgan Brooks of the Electrical Engineering Department and to Mr. H. D. Oberdorfer of the Supervising Architect's office for their interest and suggestions in the work of this thesis, and to Messrs. Fast and Simms of the class of 1909 for suggestions contained in their thesis on the same subject.